

Data arrangement and method for dental-care quality assurance

Field of invention

5 The invention relates to a data arrangement for dental-care environment and especially to storing and transmitting dental-care-related data in connection with dental-care equipment.

Prior art

In connection with dental care, data of, *inter alia*, patients, materials used in care and/or updates of patient care history are typically registered. Electronic databases enable convenient archiving of data compared to patient
10 indexes on paper. It is easy to handle data afterwards in electronic format and one is able to check what kind of treatment a patient has received. It is also easy to transfer data between clinics, for example, when a patient requires certain treatment the other dental clinic has not been able to offer or when a patient starts using services of a new dentist.
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A problem in applying an electronic data system is that someone has to make the required register entries and updates in the database. Manual data entry takes time, and errors may occur in entering and updating. In the dental-care environment, systematic data entry during each treatment stage or
20 immediately after the treatment stage is rarely possible, but one may have to first make temporary notes, whereupon the actual data entry will be made after the patient has left. The possibility of entry errors grows when data is handled manually possibly many times and especially if data is entered afterwards only by heart. Faultless data entry requires, in addition, that the registrar of data
25 knows which data to enter, in which format and whereto. Furthermore, for example capturing of many operation parameters of a dental unit during treatment would require such special arrangements, which are not possible for practical reasons. Thus, treatment histories are typically such that based on them it is practically impossible to establish afterwards and with certainty what
30 treatment the patient was actually given and how. It is essential from the viewpoint of dental-care quality that proper materials and instruments are used in dental procedures, that the instruments are properly cleaned or sterilised, and that they are used in a proper way. This kind of data is not typically entered to the treatment history, let alone such data would be entered so that one could
35 trust or at least assume that the data corresponds to what was actually done.

Summary of invention

The object of the invention is thus to develop a method and an apparatus implementing the method in order to solve at least some of the abovementioned problems. The object of the invention is achieved by an arrangement, a method, a dental care device and a software product which are characterised by what is said in the independent patent claims. The advantageous embodiments of the invention are subjects of the dependent claims.

A solution according to the invention is based on a data arrangement in a dental-care environment, which comprises a dental-care-related device and a data system. According to the invention, data transmission communication is arranged between the dental-care-related device and the data system. In the invention, the dental-care-related device identifies procedures performed by it. When the dental-care-related device has identified a procedure, data of the procedure in question is transmitted from the device to the data system as a response to identifying the procedure. The data is stored in the data system to the object of the procedure in question object-specifically.

An advantage of the solution according to the invention is, *inter alia*, that one may store information related to individual dental sessions more extensively and in more detail. By means of it, it is possible to establish afterwards which treatment the patient was given, how it was given and by which equipment. Thus, a dental clinic can show, if required, that no malpractice has occurred, whereby the possible malpractice accusations may be resolved. When information related to dental care is stored in the data system quickly and reliably already during treatment, one achieves better quality assurance of dental care than before. Because of the invention, data related to the different stages of dental care work may be stored more extensively and in more detail than conventionally has been done. It is advantageous from the viewpoint of the dentist that there is at his/her disposal detailed data in electronic format which is easily processable and from which one may verify how the treatment stages have been carried out. This is advantageous also for patient safety, and legal protection of the dentist and the patient if problems occur in the treated teeth after the treatment.

Summary of figures

The invention is now described in more detail in connection with preferable embodiments by referring to the accompanying drawings in which:

Figure 1 illustrates an arrangement according to an embodiment of the invention;

Figure 2 illustrates signalling according to an embodiment of the invention in connection with instrument sterilisation;

5 Figure 3 illustrates signalling according to an embodiment of the invention in connection with starting use of an instrument;

Figure 4 illustrates signalling according to an embodiment of the invention in connection with dental procedures;

10 Figure 5a and 5b show a flow diagram illustrating a method according to an embodiment of the invention;

Figure 6a shows a table illustrating a method according to an embodiment of the invention;

Figure 6b shows a table illustrating a method according to an embodiment of the invention.

15 Detailed specification of invention

Preferable embodiments of the invention are described in the following by referring to figures 1, 2, 3, 4, and 5. However, the purpose is not to limit the invention to these embodiments only. The invention may be applied in any dental-care environment in which electronic data entry is required. For this reason, the terms and expressions should be interpreted as broadly as possible as their function is to describe, not to limit the invention. The function is essential from the viewpoint of the invention, not in which device or network element the function is performed.

25 Figure 1 illustrates an arrangement according to an embodiment of the invention. It comprises a data system S and at least one device used in connection with dental care, which device may be, for example, a dental unit U or an instrument-sterilisation device T. Instruments X may be connected to the dental care machine U. The instrument X may be, for example, an instrument for excavating, that is, for drilling a tooth, a light curer or an instrument for finishing a filled tooth or some other instrument related to a dental procedure. 30 The data system S comprises one or more databases DB and a terminal PC. Connections inside the system S may be implemented, for example, by means of a local area network (LAN) and/or totally or partly as a wireless and/or mobile network. The dental-care-related device U, T and/or the terminal PC comprises a user interface and display means (not shown in figure 1) by means of which the data and/or messages related to dental procedures may be shown. 35

An arrangement according to an exemplary embodiment of the invention comprises at least one electronic sensor, reader device L1, L2, keyboard, camera or similar device by means of which data of the treatments carried out, the means and materials used for treatment and/or the operation parameters and their values relating to the means that were used may be registered. These devices may be physically integrated with the devices used in connection with dental care or with the data system or they may be separate devices. The reader devices L1, L2 are, for example, barcode readers or RFT (radio frequency tag) readers, and they comprise, for example, a serial connection for connecting the device either to the data system or, for example, to the dental unit.

Figure 1 shows a situation according to an embodiment of the invention in which the RFT readers L1 are physically integrated with the dental unit U and the steriliser T, and in which the barcode reader L2 for reading the barcode of a filling material package Y is physically integrated with the dental unit U. The stock control V refers to, for example, the instrument and/or material storage. The sterilisation packages of instruments X are provided with RF identifiers which are readable by, for example, RFT readers L1 being located in connection with the dental care machine U and steriliser T. The RFT identifier, that is, RF tag is a compact identifier the function of which is based on a radio-frequency field sent by the RFT reader, and the data stored in it may be changed. The instruments X themselves may have, for example, a barcode identifying their make, model and/or the individual instrument. The material packages Y are typically provided with barcode identifiers which are readable by, for example, the barcode reader L2 being located in connection with the dental unit U.

The architecture according to the embodiment of figure 1 is a simplified explanation of an embodiment of the invention, and it is well known by those skilled in the art that the arrangement may comprise also other devices, functions and structures, which there is no need to describe in detail in this context. A dental-care-related device means in this context the actual dental unit or a device used for sterilising instruments or some other device or equipment related to dental care. A dental unit is typically a multifunction unit which is used, for example, in connection with tooth excavation, filling and finishing of the filling.

Figure 2 is a signalling diagram which illustrates an exemplary embodiment of the invention in connection with sterilisation of instruments X. The instruments may be sterilised one at a time in their own sterilisation packages or as prepared sets in sterilisation packages arranged for this purpose, or one may sterilise many similar instruments at a time so that after sterilisation the instruments will be packed into sterile packages, such as sterile heat-sealable bags. In item 2-1, the identifier being in connection with the instrument X is presented to the reader device L1 of the steriliser T, which reads the identifier. In addition to this or alternatively, the identifier in connection with the instrument sterilisation package may be presented to the reader device L1. The instruments X are sterilised, and data is transmitted from the steriliser T in item 2-2 to the data system S of, for example, the point of time of sterilisation and of the fact that the instrument X in question is sterilised and packed in the sterilisation package in question. Thus, in item 2-3 data "instrument X sterilised at the point of time A" is stored in the database DB as the sterilisation status of instrument X. Also other data related to sterilisation may be stored, such as the changes of operation parameter values of the autoclave during sterilisation. After this, the instrument X is ready to be taken into storage or to be installed to the dental unit U.

Figure 3 is a signalling diagram which illustrates a solution according to an exemplary embodiment of the invention in connection with start of use of an instrument X, that is, upon connecting the instrument X to a dental unit U. In item 3-1, the identifier of instrument X or its sterilisation package is presented to the reader device L1, L2 of the dental unit U, which identifier may be, for example, an RF tag of the sterilisation package of instrument X or a barcode of instrument X, and the reader device L1, L2 reads it. As a response to reading the identifier, the dental unit U asks 3-2 the data system after the status information of instrument X and/or of the sterilisation package in question, and the status information of instrument X or its sterilisation package stored in database DB is sent 3-3 from the data system to the dental unit U. If the status information of instrument X is in order (when the database DB has no information of instrument X being used or the sterilisation package being opened since the previous properly performed sterilisation), in item 3-4 a message is shown on the display incorporated with the dental unit U, such as "instrument data OK", and information that the instrument X was taken in use, and the point of time of it, is transmitted 3-5 to the data system. If status of the

instrument or the sterilisation package is not appropriate, a corresponding warning or notice is shown in item 3-4. Alternatively, information that the instrument was taken in use may be transmitted to the data system not until it is acknowledged at the user interface in item 3-4 that the status data has been seen. When the data system has received a notice 3-5 of the instrument X having been taken in use, it stores the data of instrument X having been taken in use and, for example, of the fact that the instrument having been taken in use has been properly sterilised and maintained, in the database 3-6. The storing in question is preferably performed so that the data of the instrument status at that point of time in question is linked to the treatment history of the patient being treated, or the patient to be treated next.

Figure 4 is a signalling diagram which illustrates an exemplary embodiment of the invention in connection with a typical dental procedure. Figure 4 shows a situation in which the basic information of a patient has been already entered in the patient database, a treatment time is reserved for the patient and possibly also the arrival of the patient to the clinic has been entered. In item 4-1, data is entered of, for example, start of the actual treatment session, of the mouth status survey of the patient made in this connection and of preparation of the treatment plan and of it having been approved by the patient. This data may be entered in the data system S, for example, by means of a microcomputer PC or a user interface arranged to the actual dental unit, and it is stored in the database DB. The data system S may have been arranged to point out if there exist errors or deficiencies in the data, for example, if some piece of information related to the patient, the tooth being treated or the treatment process is missing. A notice of storing the data may be transmitted (not shown in figure 4) to the dental unit U, and a message of the data being entered and stored in the electronic patient card (patient database) may be shown, for example, on the display connected to the dental unit. The data system may also be arranged to transmit (not shown in figure 4) to the dental unit a treatment plan and instrument data, such as control signals related to the hand piece and/or head used according to the treatment plan in question, based on which control signals, for example, the values of power or rotation speed to be used are shown as a response to receiving the signals in question in the dental unit.

In the embodiment according to figure 4, the procedure according to the treatment plan is removal of caries. Typically, at this stage the dental-care

instruments X are connected to the dental unit U following the principles described in connection with figure 3. The arrangement preferably comprises a reminder function in a situation in which one attempts to use an instrument without entering or choosing data of where to the procedure is targeted, such as data of the patient, the tooth to be treated and/or a certain surface of the tooth. Then, a corresponding notice may be shown on the display connected to the dental unit U. The dental procedure according to figure 4 may comprise drilling of the tooth, whereupon the control system of the dental unit identifies 4-2 the procedure, that is, in this case drilling. The identification of the procedure may be based on, for example, identifying lifting of the instrument X from the dental unit instrument table. Data of taking the instrument in use, and how it was used, is transmitted 4-3 to the patient database in which is stored 4-4, for example, data "properly at the point of time A sterilised instrument X was used at the point of time B for drilling tooth H of patient P by the drill operation parameter M, N, O values m, n, o". Operation parameter values to be stored may be, for example, drilling times, power and rotation speed, which data related to the drilling stage is thus transmitted 4-3 to be stored 4-4 in the database as a response to the use of drill in item 4-2.

Filling of a tooth is started by first identifying a material package Y in item 4-5. At this stage, the barcode identifier in the filling-material package Y is presented to a barcode reader L2 arranged in connection with the dental unit, the reader reads the barcode identifier and transmits its data to the dental unit U. The dental unit requests 4-6 from the data system S the data of the filling-material package Y in question, which data has been stored earlier in the database DB upon stocking, and possible prior use of the package ("package" may in this connection refer to, for example, a package including disposable ampoules or an individual package/ampoule). Data of opening and/or use of the package is updated 4-7 in the database DB. The status data of the package is transmitted 4-8 to the dental unit U. After this, a notice is shown 4-9 on the dental unit display of the use-by date, the storing situation of the filling material in question and/or, for example, a comment that there is also other material in the storage that could alternatively or even better be suited for use according to the treatment plan of the patient in question. Alternatively, the data in question may be shown on the terminal PC of the data system. In this context, the data system may also be configured to control the dental unit so that its instrument-specific operation parameters are set to preset values applicable

in the filling function. In item 4-9, the cavity in the tooth is filled with filling material, and the material is cured by a light curer instrument. The curing is typically done in layers, in which case the filling comprises more than one filling and curing stages. Data of the operation parameters of these curing stages, such as the starting and ending time of each curing or the lengths of curing stages and possibly the power of the light-curing instrument, may be sent 4-10 from the dental unit to the data system S and be stored in the database DB already during the procedure, for example, as a response to the use of the light-curing instrument. Data on consumption of the filling material, such as the number of ampoules used, may also be stored in the database DB. Data of material consumption may be stored both in patient-specific data and stock control. Finally, the dental-care personnel registers that the treatment has been performed by, for example, an electronic signature, and the patient is checked out in item 4-11, whereupon the data of checking out and its time is stored in the database DB. Thus, one may easily acquire data from the data system later on that the patient P being treated at the point of time C so that a certain amount of filling material Y was used according to the treatment plan in question for filling the cavity, and that the material was cured in a certain number of stages using the light-curing instrument X by a certain power or powers, in which case, in light of this data, one may afterwards evaluate if the filling was properly performed.

Figure 5a is a flow diagram, which illustrates procedures according to an exemplary embodiment of the invention, performed in the data system S. In item 5-1, the data system S receives from the steriliser T data of sterilisation of an instrument X and, for example, the point of time of sterilisation and that the instrument X in question is packed in a certain sterilisation package. After this, in item 5-2 data, such as "instrument X sterilised at the point of time A", is stored in the data system database DB as the sterilisation status of instrument X. Also other data related to sterilisation may be stored in item 5-2, such as the changes of operation parameter values of the autoclave during sterilisation.

In item 5-3, the data system receives from the dental unit U a request of status data of an instrument X and/or a sterilisation package, and in item 5-4, the status data of instrument X or its sterilising package stored in database DB is retrieved to the dental unit U. If the status data of the instrument X is in order (when the database DB, for example, has no data of the instrument X being used or the sterilising package being opened since the previous properly performed sterilisation), a notice is transmitted 5-5 to the dental unit,

such as "instrument data OK". If the status of the instrument or the sterilisation package is not appropriate, a corresponding warning or notice is transmitted 5-6 to the dental unit. In such a case, the dental-care personnel should check if it seems that there is uncertainty of the sterility of the instrument, and, if required, replace the instrument with another one. In item 5-7, data of taking instrument X to use and the point of time it was done is received. When the data system has received a notice of taking the instrument X to use, it stores 5-8 in the database DB the data of taking the instrument X to use and, for example, of the fact that the instrument that was taken to use has been properly sterilised and maintained.

In item 5-9, data is received of start of the actual treatment session, of the survey of the mouth status of the patient and preparation of the treatment plan and having it approved by the patient made in connection with it. In item 5-10, the data in question is stored in the database DB. The data system S may have been arranged to check in item 5-11 if there are errors or defects in the data, for example, if data of the patient, the tooth to be treated or the treatment process is missing or if data is entered in the data system or if data of whereto the procedure is directed has been chosen, such as data of the patient, tooth to be treated and/or the surface of the tooth to be treated. A warning or notice of possible errors or defects is sent in item 5-12 to the dental unit or the terminal PC. Alternatively, in item 5-13, a notice of the data being properly entered and stored is transmitted to the dental unit U. After this, the process of figure 5a continues, for example, in a manner as described in connection with figure 5b below.

Figure 5b is a flow diagram, which illustrates procedures according to an exemplary embodiment of the invention, performed in the data system S. The process of figure 5b is a continuation of, for example, items described in connection with figure 5a above. In item 5-14, data is received from the dental unit control system of what kind of dental procedure, for example, drilling, was performed by the dental unit U and data of this is stored 5-15 in the database DB, in which is stored, for example, data "properly at the point of time A sterilised instrument X was used at the point of time B for drilling tooth H of patient P by the drill operation parameter M, N, O values m, n, o".

In item 5-16, a request is received from the dental unit concerning filling-material package Y data which has been stored in the database DB earlier upon stocking the package and upon its possible prior use. The status data

of the package is transmitted 5-17 to the dental unit U, such as data of the use-by date, storage situation of the filling material in question and/or, for example, a comment that there is also other material in the storage which could alternatively or even better be suited for use according to the treatment plan of the patient in question. Data of opening and/or use of the package is updated 5-18 in the database DB. The data in question may also be shown on the terminal PC of the data system. The filling of the tooth is performed typically in layers, in which case the filling comprises more than one filling and curing stage. Data of the operation parameters of these curing stages, such as the starting and ending time of each curing or the lengths of curing stages and possibly the power of the light-curing instrument, are received 5-19 from the dental unit and stored 5-20 in the database DB already during the procedure. Data of consumption of the filling material, such as the number of ampoules used, may also be stored in the database DB. Data of material consumption may be stored both patient-specifically and in the stock control. Finally, data of checking out of the patient is received and stored in item 5-21.

Items and signalings described in figures 2, 3, 4, 5a, and 5b may also be implemented in other order than described here, and there may be other functions between them or only part of the functions may be performed. The items and signalling messages described may also include other than the data presented, or they may include only part of the data presented above. For example, only part of the items described in figures 5a and 5b may be performed, for example, items 5-1, 5-2, 5-7, 5-8, 5-9, 5-10, 5-14, 5-15, 5-18, 5-19, and 5-20. The procedures may also be repeated more than once, in case needed.

Figures 6a and 6b describe by way of examples how the elements and equipment related to dental-care situations function in an environment according to the invention in relation to each other in connection with some procedures related to dental care.

In this patent application, by the term "store" is meant short- or long-term storing of information related to dental-care events depending on what is expedient in each case from the viewpoint of assurance of legal protection of the patient and the dental clinic or control of the dental unit in contemplation of later utilisation of the data and quality assurance of dental-care work. The information may be stored in an "electronic patient card" or otherwise controllably so that it can be searched from the data system when required and may be

linked to the correct patient, care personnel, device, treatment event and/or date and time *etc.* Thus, information of the item of the procedure will be stored in the data system item-specifically. The item may be, for example, a dental-care instrument, material used in dental care or its package, a patient card or a certain tooth or a certain tooth surface of the patient.

Data transmission and storing may take place so that when a dental-care-related device is used, data is transmitted electronically e.g. from the control system of the dental-care-related device to a data system, whereat data of, for example, the device and instruments that are being used, and durations of their use and their operation parameter values will be stored in the data system. This data is transmitted and stored according to the invention from, for example, the dental unit control system the software pertaining to which "knowing" and "deducting" different items related to the dental unit functions, such as which instrument is being used, how long it is used, which variables the use of the instrument requires and which are the current (control) values of the respective operation parameters *etc.* For example, when the operating system controls power of the light-curing instrument controlled via the foot controller of the dental unit, the software knows that the light-curing instrument is now on and may calculate its operating time.

When one arranges into connection with a dental-care-related device at least one such a device, for example, an electronic reader device, a keyboard, a sensor, a camera or a similar device via which it is possible to receive data of the dental procedures performed, the treatment instruments, materials and/or the operation parameter values of devices and/or instruments used in treatment in electronic format, one may also store such a data in a desired location. For example, by means of an electronic reader device, such as a barcode or RFT reader, a dentist or dental hygienist may read and store a proper barcode identifier or other identifier readable with a reader device directly in connection with the treatment session. The identifier may be, for example, a barcode on the sterilisation package of a dental-care instrument or on a filling material package. In addition to thus enabling immediate storing data of, for example, the filling material used in connection with the treatment event, one will be able to check at the same time from the data system that the material package in question is not e.g. out-of-date or that the material itself is not inapplicable for the planned use for some other reason.

According to an embodiment of the invention, information related to dental-care events comprises at least one of the following data related to dental-care instruments and/or their use: data of the type of a dental-care instrument, identification data of the dental-care instrument, maintenance status
5 data of the dental-care instrument, sterilisation status data of the dental-care instrument, data of the point of time of sterilisation of the dental-care instrument, data of connecting the dental-care instrument to the dental unit, data of taking the dental-care instrument in use in connection with a treatment event, data of the point of time when the dental-care instrument was taken in use,
10 data of operation parameter values of the dental-care instrument during the dental treatment event comprising data of operation time, rotation speed and/or power used, data of disconnecting the dental-care instrument from the dental unit, data of the point of time of disconnection of the dental-care instrument, data of starting and ending the sterilisation treatment of the dental-care
15 instrument, data of the starting and ending time of the sterilisation treatment of the dental-care instrument, and sterilisation process parameter values during sterilisation.

According to an embodiment of the invention, information related to dental-care events comprises at least one of the following data related to dental-care materials and/or their use: data of material used in dental treatment,
20 data of the point of time of arrival of the material package used in dental treatment to the clinic, identifying data of the material package and/or its manufacturing lot, data of the use-by date accordant with the material package, data of opening the material package, data of the point of time of opening of the material package, data of the point of time of use of the material, data of the amount
25 of material used.

According to an embodiment of the invention, information related to dental-care events comprises a treatment plan of a patient, data of performing a certain treatment procedure, and/or data of the point of time the procedure
30 was performed.

According to an embodiment of the invention, the data system may also be arranged to transmit, as a response to storing a treatment plan of a patient, to the dental unit control signals, which relate to treatment plan and instrument data such as the hand piece and/or head, for example, for presetting
35 the values of power or rotation speed to be used in the dental unit.

According to an embodiment of the invention, the data system may be arranged to transmit, as a response to taking a filling material package to use, to the dental unit control signals based on which instrument-specific operation parameters will be set to the preset values applicable in the filling procedure.

According to an embodiment of the invention, data will be sent from the data system to the stock control V of the material packages and/or instruments that have been used, whereby it is possible to update the material and/or instrument stock balance in the stock control. In an arrangement according to the invention, the stock control may be configured to warn if the amount of certain material in the storage is below a predetermined amount, whereby an order for additional material may be placed in time.

According to an embodiment of the invention, an instrument is provided with a non-volatile memory (EEPROM, electrically erasable programmable read-only memory) in which is stored identifying data of the instrument, which data may be read by a dental-care-related device U, T.

A data arrangement implementing the functionality according to the present invention comprises, in addition to that of the prior-art, means for identifying and storing events item-specifically. To be more precise, it comprises means for implementing at least one of the embodiments described above. Personal computers or terminals and database servers today comprise processors and memory, which may be utilised in operations according to the invention. All changes and configurations required to implement the invention may be performed as added or updated software routines, with application-specific integrated circuits (ASICs) and/or by configuring an existing system in other ways. The software/software routine(s) may be stored on any kind of data storage device, which is readable by a computer.

By means of the invention, it is possible to improve the quality assurance of dental care when the data related to different procedures of the treatment may be stored extensively and directly already in connection with the treatment event. For example, if a patient claims having caught hepatitis from the dental clinic, one will be able to verify from the data system if the instruments used in connection with the treatment event have been properly sterilised. On the other hand, if the manufacturer of filling material notifies that a certain material lot has perished, one obtains data from the data system of those patients whose fillings need to be replaced. An arrangement according

to the invention may be utilised also in other clinic functions, such as stock control. In addition, entering and storing data has been advantageously arranged as automatic as possible, whereby the care personnel may spend as little time as possible for manual entering and storing of different data. In addition, data stored in the data system may be utilised in controlling the dental unit, in addition to control commands given via user interface of the dental unit, such as push buttons and foot control.

It is well known by those skilled in the art that upon advancing of technology, the basic idea of the invention may be implemented in many different ways. The invention and its embodiments are thus not limited to the examples described above but may vary within the scope of the patent claims.